VERIFICATION OF TRANSLATION

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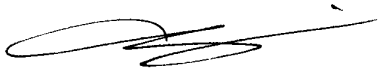
Japanese Patent Application No.2003-049396, filed on February 26, 2003

Signature of Translator: 

Wakako Anzai

Date :June 20, 2007

(TRANSLATION)

PATENT OFFICE
JAPANESE GOVERNMENT

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No. 2003-049396

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[Type of Document] Specification

[Title of the Invention] Display and display apparatus

[Scope of Claims for Patent]

[Claim 1] A display element comprising:

a display layer that includes a light-emitting element; and

an output layer that is transparent, is disposed in an emitting direction of the display layer, and includes an angle changer that changes a direction of light output from the light-emitting element to a direction of the emitting side, wherein

a refractive index of the output layer is either almost the same as or greater than a refractive index of the light-emitting element.

[Claim 2] The display element according to claim 1, wherein the angle changer is any one of a micro lens, a micro prism, and a micro mirror.

[Claim 3] The display element according to claim 1, wherein the display layer includes a transparent electrode layer, and the transparent electrode layer has a refractive index greater than that of the light-emitting element and sandwiches the light-emitting element.

[Claim 4] The display element according to claim 3, further comprising an antireflective layer in an interface between the transparent electrode layer and the output layer.

[Claim 5] The display element according to claim 1, further comprising a sealing layer that is transparent, and is disposed in an emitting direction of the output layer, wherein an inert gas that has a refractive index of almost one and is filled between the output layer and the sealing layer.

[Claim 6] A display panel comprising a plurality of

display elements according to claim 1, and the display elements are arranged two-dimensionally in a matrix form.

[Claim 7] A display apparatus comprising:

a display panel according to claim 6; and

a drive unit that drives the display layer of the display panel and displays an image.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a display panel using a self-emitting element such as an organic electro-luminescent element (hereinafter, "organic EL element").

[0002]

[Prior Art]

In recent years, self-emitting flat panel displays (hereinafter, "FPD") such as display panels including light-emitting elements (e.g., organic EL elements) or plasma display panels (hereinafter, "PDP") have been developed. Furthermore, a display panel in which LEDs as self-emitting elements are arranged two-dimensionally in a matrix form is also developed. The light is radially output from the display panel which includes the self-emitting elements. Since the light is emitted from the light-emitting elements in a transparent medium that has a refractive index more than one, there is a critical angle, where the light is not radiated to external medium, at an interface between the panel and the external medium. Among the light radiated from the light-emitting layer, the light having an incident angle not less than the critical angle with respect to an interface on a transparent layer on the surface of the display panel undergoes reflection at the interface and is confined in the display panel. Due to this, only a certain amount of light can be used, when compared to the total amount of light that is actually output from the display panel. In the case of the organic EL elements, only about 20 to 30 percent of total light, emitted from the organic EL elements, is emitted out of the display panel.

[0003]

To solve the problems about the light use efficiency and the light extraction efficiency, a technology is disclosed for forming a specific portion that reflects or refracts light having the critical angle or larger to adjust a traveling direction of the light, thereby converting the light into light having an angle smaller than the critical angle. The specific portion is provided inside a protection layer configured to form an output side of a display panel or inside a transparent panel functioning as an outer layer. Japanese Patent Application Laid-open No. 10-189251 discloses a configuration in which a wedge-shaped reflecting member is disposed at a periphery of the light-emitting layer, thereby forming a reflectable slope structure. In the reflectable slope structure, a predetermined groove is formed in the transparent panel, thereby the wedge-shaped reflecting member is formed by vapor-depositing the predetermined groove with metallic material.

[0004]

[Patent Literature 1] Japanese Patent Application Laid-open No. 10-189251

[0005]

[Problem to be Solved by the Invention]

It is possible to improve the light extraction efficiency by providing the angle changing structure that changes the direction of the output light from the light-emitting elements, in the transparent panel. However, there is further request that the amount of the light emitted from the display panel is to be improved. Even if the angle changing structure is provided, all of the light emitted from the light-emitting elements is not emitted to the external medium through the display panel.

[0006]

In a display panel in which a protective layer is deposited on a display layer that includes the light-emitting element, not all the output light from the light-emitting element is output to the external medium. One of the causes of this is that there is an interface also between the light-emitting element and the protective layer and if the refractive index of the protective layer is lower than the refractive index of the light-emitting element, there is a critical angle when the light is input from the light-emitting element to the protective layer. For example, as shown in Fig. 11, in a general structure of a display panel 90 in which the organic EL elements are sandwiched between the electrode 20 and the electrode 21 as light-emitting elements 11, a glass substrate 92 is disposed as a protective layer on the display layer 10 formed on a substrate 5. The refractive index of the glass substrate 92 is 1.5 while the refractive index of the light-emitting element 11 is 1.7. The light emitted from the light-emitting element 11 and passed through an electrode 20 contains a component that undergoes total reflection at the interface 95. Therefore, as shown in Fig. 11, out of the light emitted from the light-emitting element 11, the light 98 having an angle of incidence on the glass substrate 92 not less than the critical angle is reflected at the boundary 95 of the glass substrate 92 and this light cannot be extracted.

[0007]

If the refractive index of the transparent panel on the display layer as a protective layer or an output layer is made greater than the refractive index of the light-emitting element, the light that is input from the display layer to the transparent panel does not contain a component of total reflection. Therefore, the light emitted from the

light-emitting element can be input to the transparent panel. However, if the refractive index of the transparent panel is increased, the difference between the refractive index of the transparent panel and that of air (i.e., an external medium) becomes greater and the critical angle of the light with respect to an interface between the transparent panel and the external medium becomes smaller. Due to this, even if the transparent panel having a refractive index greater than that of the light-emitting element is used, the amount of light that is extracted in the external medium does not increase. Therefore, the light extraction efficiency cannot be improved.

[0008]

It is an object of the present invention to provide the display element, which improve light extraction efficiency and thereby more light emitted from the light-emitting element is output to an external medium, and a method of manufacturing the self-emitting element. It is another object of the present invention to provide the display apparatus that can display the brighter image by providing the display apparatus using the display panel.

[0009]

[Means for Solving Problem]

In the present invention, refractive index of a transparent output layer that includes the angle changer, which changes the direction of the light emitted from the light-emitting element into the direction of emission, is the same or greater than the refractive index of the light-emitting element. This is to achieve input of the light in the output layer without any leakage of light. Also, the light incident on the output layer is directed at an angle smaller than the critical angle of the interface between the output layer and the external medium. This is to

enable output of the output light efficiently to the external medium even if the output layer has a high refractive index. In other words, the display element according to the present invention includes a display layer that includes the light-emitting element and the transparent output layer that includes the angle changer. The angle changer is disposed in the direction of emission of the display layer, and directs the light emitted from the light-emitting element in the direction of emission. The refractive index of the output layer is the same as or greater than the refractive index of the light-emitting element.

[0010]

By making the refractive index of the output layer same or greater than that of the light-emitting layer, the light directed from the light-emitting element or the display layer to the output layer has no component that undergoes total reflection. All the light emitted from the front or the top of the light-emitting element excluding light emitted from the bottom of the light-emitting element is extracted in the output layer. By providing in the output layer the angle changer that changes the direction of the light by reflection or refraction, the direction of the light having a bigger angle of incidence with respect to the interface between the output layer and the external medium is changed so that the angle of incidence with respect to the interface is smaller. Even if the critical angle in the boundary with the external medium becomes smaller due to increase in the refractive index, it can be input to the external medium by making the angle of incidence smaller than the critical angle. Thus, the light extraction efficiency can be maintained or improved. Therefore, the display element according to the present

invention enables to reduce loss when the light is incident on the output layer from the light-emitting element or the display layer. As a result, the efficiency of light emitted from the light-emitting element can be improved.

[0011]

A micro lens or a micro prism that changes the direction of light by refraction or a micro mirror that changes the optical path by reflecting the light can be employed as the angle changer that changes the optical path of the light in the output layer. The micro lens can also be used as the output layer.

[0012]

Even if an output layer having a high refractive index is prepared, if an intermediate layer having a refractive index smaller than that of the light-emitting element is disposed between the light-emitting element and the output layer, the light incident on the output layer is reduced by a component that undergoes total reflection at the interface of the intermediate layer. On the other hand, even if an intermediate layer having a refractive index greater than that of the output layer is disposed between the light-emitting element and the output layer, the light emitted from the light-emitting layer is incident on the output layer at less than the critical angle through the intermediate layer. Therefore, there is no loss of light in the intermediate layer. For this reason, it is necessary that the refractive index of the intermediate layer is greater than that of the light-emitting layer. If the light-emitting element is an organic EL that emits light when a voltage is applied, it is necessary to deposit a transparent layer, which is an electrode for applying voltage to the light-emitting element, on the display layer. This transparent electrode layer becomes an intermediate

layer between the light-emitting element and the output layer. Therefore, by making the refractive index of this transparent electrode layer greater than that of the light-emitting element, the loss of the output light in the transparent electrode layer can be minimized.

[0013]

On the other hand, when the difference between the refractive indices of the output layer and the transparent electrode layer is high, there is a reflection of light at an interface of the output layer and the transparent electrode layer due to difference in the refractive index and the efficiency of light is reduced. Moreover, when an external light is incident, due to reflection of the external light at the interface, the contrast is reduced. Therefore, it is desirable to improve the efficiency of light by providing an anti-reflective layer in the interface between the transparent electrode layer and the output layer and also minimize the reflection of the external light.

[0014]

Light output from the output layer functions effectively when passing through air (refractive index of air is approximately one) and reaching eyes of a user. A transparent sealing layer may be provided in the direction of emission of the output layer across a space from the output layer. In this case, even if the space is filled with an inert gas having a refractive index of approximately one and the sealing layer is formed by a material having a refractive index of approximately 1.5, all the light input from the output layer to an inert gas layer can be input to the sealing layer. Further, since the refractive indices of the inert gas layer and an air layer on the user side are almost the same, all the light

input to the sealing layer can be extracted in air.

[0015]

Thus, the display element according to the present invention can improve further the efficiency of the light emitted from the light-emitting element, thereby enabling to output light having high brightness. Therefore, a display panel in which a plurality of self-emitting elements (display elements) are arranged two dimensionally in a matrix form can provide sharp images having high brightness. Moreover, a display apparatus that includes the display panel according to the present invention and the drive unit that displays images by driving the light-emitting element of the display panel makes it possible to display even brighter image at low electric power.

[0016]

[Embodiments of the Invention]

The present invention is explained in detail below with reference to the accompanying drawings. A portable telephone 1 shown in Fig. 1 is a display apparatus including a display panel and a drive unit according to the present invention. The display panel 3 of the portable telephone 1 includes a display layer 10, where the organic EL elements as the self-emitting light-emitting elements are disposed in the form of a matrix, and an output layer 30. The light 8 emitted from the light-emitting element is output to a user 9 and display characters and images to the user 9.

[0017]

Fig. 2 is an enlarged view of a part of cross section of a display 4 included in the display panel 3. The display panel 3 includes a substrate 5, a display layer 10, and an output layer 30 that are deposited in order on the substrate 5. The display element 10 is separated by a bank

12 made of polyimide. The organic EL element disposed two dimensionally in a matrix form is taken as a light-emitting element 11 which is a light-emitting layer. This light-emitting element 11 is sandwiched between an electrode 20 and an electrode 21. Out of these two electrodes, the electrode 20 on the side of the output layer 30 is a transparent electrode of a material like ITO. Therefore, for each light-emitting element 11, the substrate 105, the display layer 10, and the output layer 30 are deposited one above the other to form the display element 4. The display panel 3 includes a plurality of the display elements 4 disposed in the form of a matrix. In the display panel 3 that includes the organic EL elements as the light-emitting elements, the refractive index of the light-emitting element is 1.7. If the transparent electrode layer 20 is made of ITO, the refractive index becomes approximately 2.0.

[0018]

The whole of the output layer 30 disposed on the light-emitting side of the transparent electrode layer 20 is transparent. A sheet 31 is provided with a reflecting plate 32 that reflects light 8 emitted from the light-emitting element 11. The sheet 31 having the reflecting plate is stuck to the display layer 10 by a transparent adhesive layer 33. The sheet 31 and the adhesive layer 33 in the present embodiment are formed by an aryl resin that includes a large number of multiple bonds like a double bond and a triple bond, and the refractive index is made to be approximately 1.7. Therefore, in the display panel 3 in this embodiment, the refractive index of the output layer is about the same as that of the light-emitting element 11. Due to this, at a first interface 30b between the display layer 10 and the output layer 30, out of the light emitted from the light-emitting element 11, there is no component

in the output light 108 that is output in a direction D1 (direction of emission or forward direction) of a user 9 and that undergoes total reflection. Thus, the whole of the output light 8 from the light-emitting element 111 is transmitted to the output layer 30.

[0019]

Actually, the refractive index of the transparent electrode layer 20 is about 2.0 and when the refractive index of the output layer 30 is less than that of the transparent electrode layer 20, there is a total reflection of the output light 8 at the first interface 30b. However, the whole of the light 8 transmitted from the light-emitting element 11 to the transparent electrode layer 20 is input to the first interface 30b at an angle not greater than the critical angle. Therefore, even if the refractive index of the output layer 30 is less than the refractive index of the transparent electrode layer 20, the output light 8 is not reflected totally at the first interface 30b. Due to this, if the refractive index of the transparent electrode layer 20 is either same or greater than that of the light-emitting element 11, by comparing the refractive indices of the light-emitting element 11 and the output layer 30, the judgment of whether the output light 8 from the light-emitting element 111 is transmitted to the output layer 30 or not can be made.

[0020]

On the other hand, when the refractive index of the transparent electrode layer 20 is less than the refractive index of the light-emitting layer 11, a part of the output light 8 is reflected totally at the interface of the transparent electrode layer 20 and the light-emitting element 11. Therefore, there is a decline in the efficiency of the output light 8.

[0021]

In the display panel 3 of this embodiment, out of the output light 8 input to the output layer 130, the light input to an interface 30a at an angle smaller than the critical angle at the interface 30a being an interface with the external medium, passes through the interface 30a and is output to the external medium. Whereas, out of the output light 8 input to the output layer 30, the light having an angle of incidence greater than the critical angle is reflected by the reflecting plate 32 on the sheet 131 so that the angle of incidence at the interface 30a becomes smaller. Therefore, the light that is input to the output layer 30 is output directly or after being reflected at the reflecting plate 32 passes through the interface 30a and is output to the external medium 50.

[0022]

Fig. 3 is a graph indicating a relationship between the proportion of incidence (incidence rate) of the output light 8 on the output layer 30 and the refractive index of the output layer 30 when the refractive index of the light-emitting element 11 is 1.7. If the refractive index of the output layer 30 becomes greater than that of the light-emitting layer 111, incidence ratio becomes one. This indicates that there is no loss due to total reflection. When a glass substrate that contains silica as a main component is used, since the refractive index is approximately 1.5, the incidence ratio becomes 0.78. Therefore, by increasing the refractive index of the output layer 30 than that of the light-emitting element 111, the proportion of the output light input to the output layer increases by approximately 30 percent. Due to this, if the output light 8 input to the output layer 30 is output to the external medium from the external layer 30, the

efficiency of light can be improved by about 30 percent according to the present invention.

[0023]

Resins that contain multiple bond like double bond, triple bond etc. are desirable as resins having a high refractive index of not less than 1.7 and it is easy to achieve high refractive index with aryl resins.

[0024]

Fig. 4 to Fig. 6 are cross sectional views that depict the manufacturing process of the display panel 3 in Fig. 2. As is shown in these diagrams, the substrate 5 on which the display layer 10 having the organic EL element 11 deposited in the form of a matrix is prepared (Fig. 4). Apart from this, a protrusion 34 that is trapezoidal in shape is formed on the lower surface in the form of a matrix. The sheet 31 is prepared by providing the reflecting plates 132 on inclined surfaces of the protrusion 34 (Fig. 5). Then, as is shown in Fig. 6, the sheet 31 is stuck by the adhesive layer 33 so that a side of the display layer 10 of the substrate is covered by the sheet 31. Thus, the display panel 3 can be prepared manufactured. The compositions of or the materials of the sheet 31 and the adhesive layer 33 may be the same or may be different. The composition or the material is to be selected so that the refractive index of each layer is greater than the refractive index of the light-emitting element 11. One of the embodiments is an aryl resin. Besides this, high refractive index can be achieved by a resin that contains a large number of multiple bonds like double bond and triple bond.

[0025]

As mentioned above, the output light 8 input to the output layer 30 is output from the output layer to the

external medium 50. To improve the output efficiency of the light 8, the reflecting plate 32 is used for changing the direction of the light. The present invention is explained with this embodiment of the display panel. However, refraction may be used for changing the direction. Fig. 7 is a cross sectional view of a different display panel 3a. The display panel 3a includes a display element 4a disposed in a matrix form. The display element 4a includes the output layer 30 that has micro lens 36 on the inner side. The micro lens 36 changes the direction of the output light 8 by the refractive surface. The output layer 30 includes a lens sheet 35 and an adhesive layer 133. The lens sheet 35 is processed so that the lower surface of the micro lens 36 forms a refractive surface. If the refractive index of the lens sheet 35 is the same as that of the adhesive layer 33, the micro lens 36 is not formed. Therefore, it is desirable that the refractive index of the adhesive layer 33 is greater than that of the lens sheet 35. Further, if the refractive index of the adhesive layer 33 is greater than that of the light-emitting element 11, similar as in the display panel 3, the output light 8 of the light-emitting element 11 is input to the output layer 30 without any leakage. The direction of the output light 8 is changed at the micro lens 36 and it can be output from the output layer 30 to the external medium 50. This enables to provide a display panel with even higher efficiency of light.

[0026]

Fig. 8 is a cross sectional view of another display panel 3b. In the display panel 3b, the micro lens 36 is the output layer 30. In the display panel 3b, a display element 4b is disposed in the form of a matrix. In the display element 4, a refractive surface being a micro lens

136 is an interface 30a with the external medium 50. In the display panel 3b, a surface of the micro lens 36 is the interface 30a. The angle of incidence of the output light 8 becomes smaller than the critical angle by changing the inclination of the interface 30a. As a result, it is possible to output the output light to the external medium 150 with improved efficiency. Thus, the efficiency of light is further improved.

[0027]

These micro lenses 36 can be formed directly on the transparent electrode layer 20 by ink-jet method. This enables to provide a thin and very bright display panel at low cost.

[0028]

Fig. 9 is a cross sectional view of still another display panel 3c. The display panel 3 includes a transparent sealing layer 40 on the emitting side of the micro lens 36. An inert gas 42 having a refractive index not less than one is filled inside the sealing layer 40. The sealing layer 40 and the inter gas 42 prevent the deterioration of the organic EL element 11 due to oxidation or absorption of moisture. The display panel 3c transmits the output light 8 to the user 9 through the external medium (air) having a refractive index of one and displays an image. For this reason, if the refractive index of the inert gas 42 inside the sealing layer 40 is less than one, the critical angle at the interface 30a between the output layer 30 and the inert gas 42 becomes smaller than the critical angle at the interface with air, thereby increasing the loss due to the total reflection. Whereas, if the refractive index of the inert gas becomes greater than one, the refractive power of the micro lens 36 decreases. Due to this, the efficiency of changing the

direction of the output light 8 to D1 is declined. Moreover, if the refractive index of the sealing layer 40 is not less than that of the inert gas 42, there is a loss due to the total reflection when the light is incident on the sealing layer 40. This imposes limitations on selection of material of the sealing layer 40. Therefore, it is desirable that the refractive power of the inert gas is approximately one.

[0029]

Fig. 10 is a cross sectional view of still another display panel 3d. In this display panel 3d a display element 4d is disposed in a matrix form. In the display element 4d, an anti-reflective layer 45 is deposited on the transparent electrode layer 20 and the output layer 30 is formed by the micro lens 36. When there is a big difference in the refractive index of the output layer 30 and that of the transparent electrode layer 20, even if the light is incident at the interface of the output layer 30 and the transparent electrode layer 20 at less than the critical angle, there is a reflection due to the difference in the refractive index and the efficiency of light is declined. Moreover, external light 7 like sun light or illuminated light that is input to the display panel 3 from the external medium 50 is reflected due to the difference between the refractive index of the output layer 30 and that of the transparent electrode layer 20. This declines the contrast of the output light 8 emitted from the light-emitting element 11. To avoid this, the anti-reflective layer 45 is disposed between the display layer 110 and the output layer 30, i.e. between the transparent electrode layer 20 and the output layer 30. This improves the efficiency of light and prevents the reflection of the external light 7. In the display panel 3, to prevent

reflection due to the difference in the refractive index of all layers, it is desirable to dispose an anti-reflective at the interface of the light-emitting element 111 and the transparent electrode layer 20. However, it is not possible to dispose an insulating anti-reflective layer between the light-emitting element 11 and the transparent electrode layer 20. Therefore, the anti-reflective 45 is disposed between the display layer 10 and the output layer 30 and the reflection due to the difference in the refractive indices is reduced as much as possible. This enables to provide the display panel 3d that can display a clear image with high contrast and high light extraction efficiency.

[0030]

In the display panels 3 to 3d mentioned above, a material having a high refractive index is used for the output layer 30 to supply the light 8 that is output from the light-emitting element 11 to the output layer 30 without leakage. The optical path is changed at the output layer 30 and the light is incident on the interface 30a with the external medium at an angle smaller than the critical angle that becomes smaller due to use of the material having a high refractive index. Thus, the efficiency of light is further improved. The direction of the output light 8 can be changed by reflection or refraction. In a case of changing the direction of the output light by refraction, it is possible to use prism instead of restricting to lens.

[0031]

According to the result of simulation in Fig. 3, with the present invention, compared to the case of not using the material having a high refractive index, it is possible to improve the efficiency of light further by about 30

percent. The present invention enables to provide a display panel that can display a clear image with high brightness at low power consumption.

[0032]

The display panel according to the present invention can be applied to many kinds of display apparatuses such as car navigation systems, monitors of computers, and televisions as well as the portable telephone explained the above. The display panel is possible to provide display a clear image with bright and to saves the power consumption. Furthermore, as explained the above, light-emitting elements are not limited to organic EL elements. The present invention can be applied to the display using another self-emitting element such as plasma display panels or LED display.

[0033]

[Effect of the Invention]

As explained the above, in the present invention, by making the refractive index of the output layer same or greater than that of the light-emitting element, the whole of the output light from the light-emitting element can be input to the output layer. By providing the angle changer in the output layer that changes the optical path, the refractive index is made greater. This enables to output the output light efficiently to the external medium to incident it at an angle smaller than the critical angle with respect to the interface of the external medium and the output layer having its critical angle decreased. Consequently, this enables to improve the efficiency of the light to a great extent that is output from the light-emitting element and to provide the control panel that can display a clear and bright image.

[Brief Description of Drawings]

[Fig. 1] A diagram of a display apparatus (a portable telephone) in which a display panel according to the present invention is installed.

[Fig. 2] A cross sectional view of the display panel according to the present invention.

[Fig. 3] A graph indicating a relationship between refractive index and incidence rate of an output layer of the display panel according to the present invention;

[Fig. 4] A cross sectional view of a substrate on which a display layer is formed in the method of manufacturing the display panel according to the present invention.

[Fig. 5] A cross sectional view of a sheet on which a micro mirror is formed in the method of manufacturing the display panel according to the present invention.

[Fig. 6] A cross sectional view of the substrate on which the sheet is stuck in the method of manufacturing the display panel according to the present invention.

[Fig. 7] A cross sectional view of still another display panel.

[Fig. 8] A cross sectional view of still another display panel.

[Fig. 9] A cross sectional view of still another display panel.

[Fig. 10] A cross sectional view of still another display panel.

[Fig. 11] A cross section view of a state of loss.

[Explanations of Letters or Numerals]

1 portable telephone

2 driving unit

3 to 3d display panel

4 to 4d display element

10 display layer

11 organic EL element (light-emitting element)
30 output layer
31 sheet having the reflecting plate
32 reflecting plate
33 transparent adhesive layer
35 lens sheet
36 micro lens
40 transparent sealing layer
42 inert gas
45 anti-reflective layer

[Type of Document] Abstract

[Abstract]

[Problem to be solved] To provide a display panel that can improve higher efficiency of light, in the display panel output the light emitted from a light-emitting element.

[Solution] In the display panel 3 in such structures in which a display layer 10 that includes a light-emitting element 11 and an output layer 30 are disposed, the refractive index of the output layer 30 is made same or greater than that of the light-emitting element 11. In addition, the output layer 30 changes the direction of light input into the output layer 30 and the light 8 is incident on the interface 30a of the output layer 30. Consequently, it is possible to reduce loss of the output light when the light is incident between the output layer 30 and the display layer 10. As a result, it is possible to provide a display element 4 and a display panel 3 that can improve the higher efficiency of the light emitted from the light-emitting element 11.

[Chosen Drawing] Fig. 2

[Type of Document] Drawings

FIG. 1

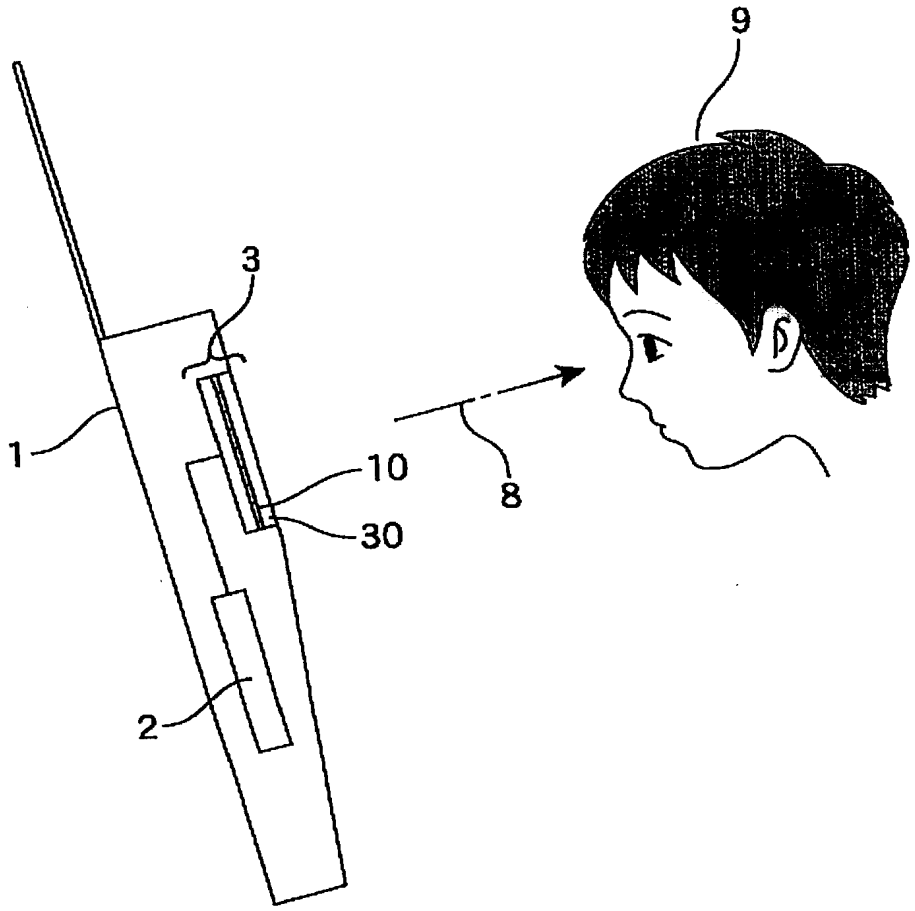

FIG. 2

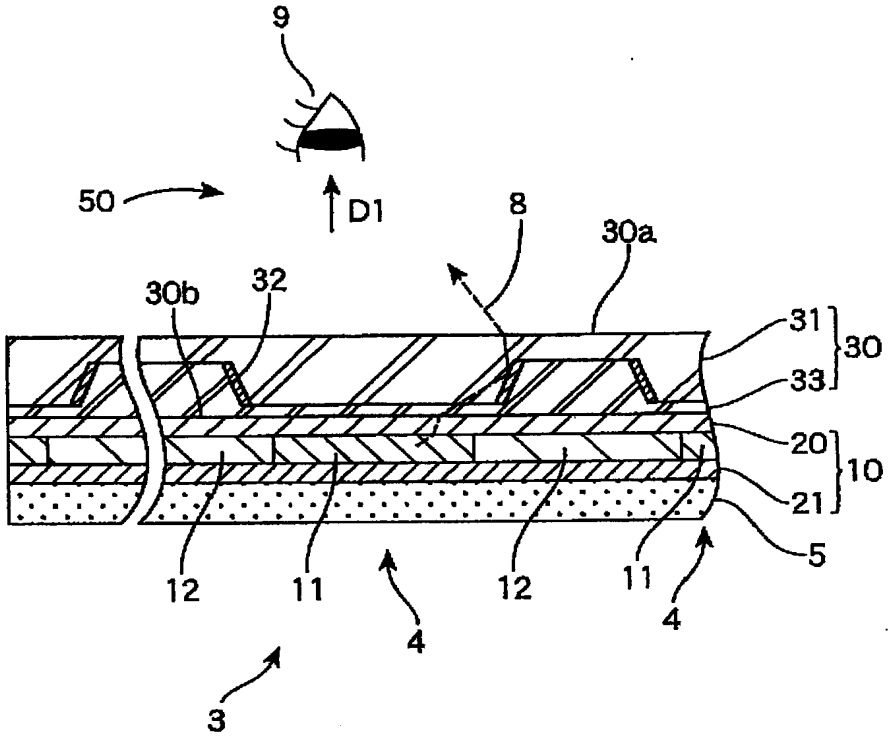
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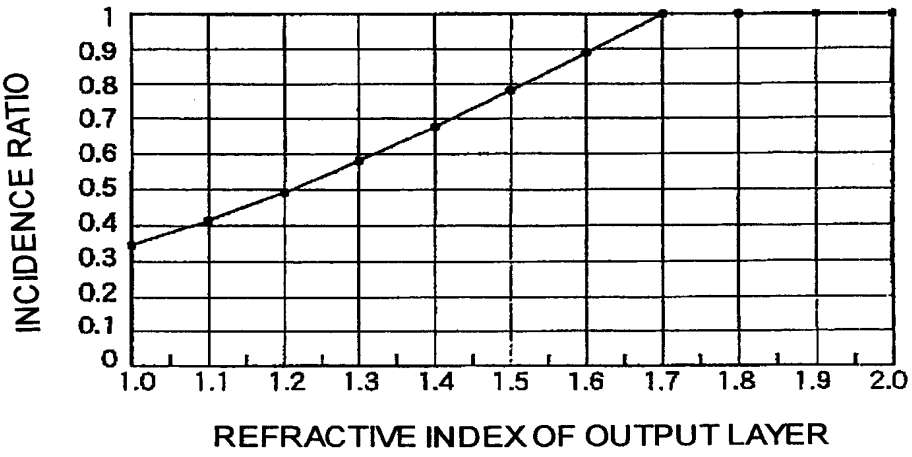
FIG. 3


INCIDENCE RATIO
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1.4
1.5
1.6
1.7
1.8
1.9
2.0
REFRACTIVE INDEX OF OUTPUT LAYER

FIG. 4

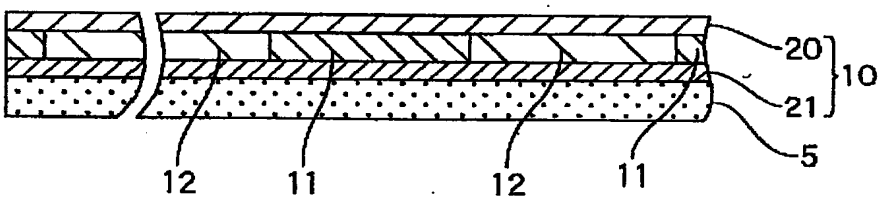

FIG. 5

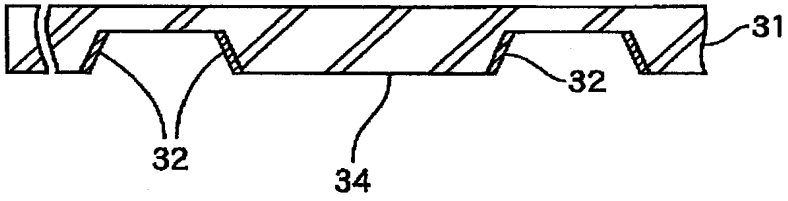

FIG. 6

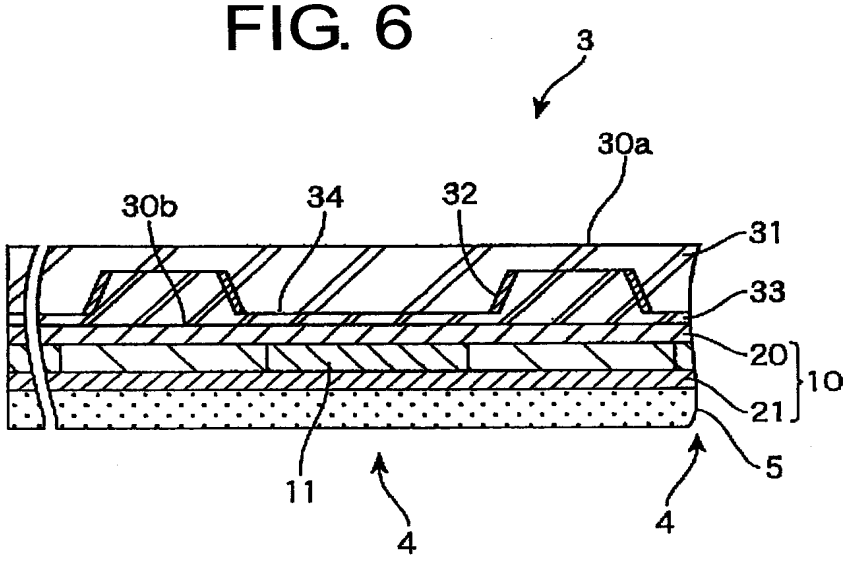

FIG. 7

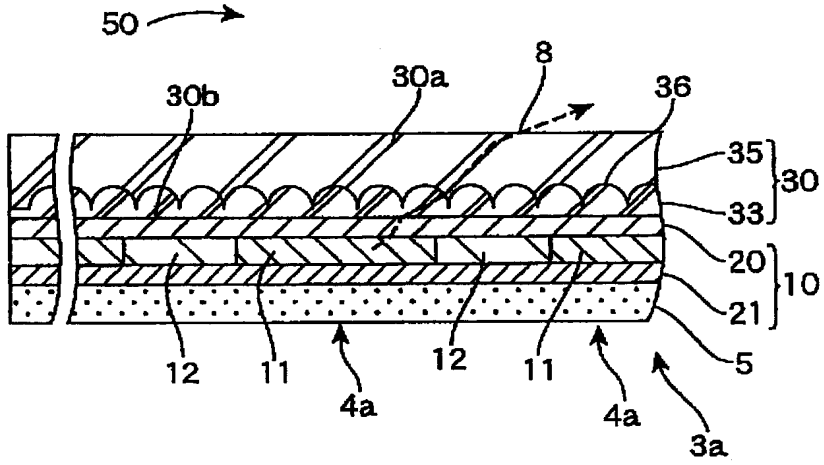
50
30b
30a
8
36
35
30
33
20
10
21
5
12
11
4a
12
11
4a
3a

FIG. 8

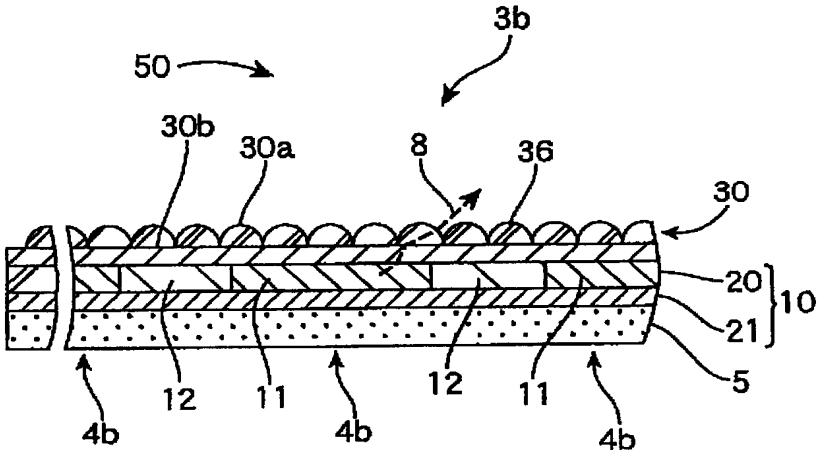
3b
50
30b
30a
8
36
30
20
10
21
5
12
11
4b
12
11
4b
4b

FIG. 9

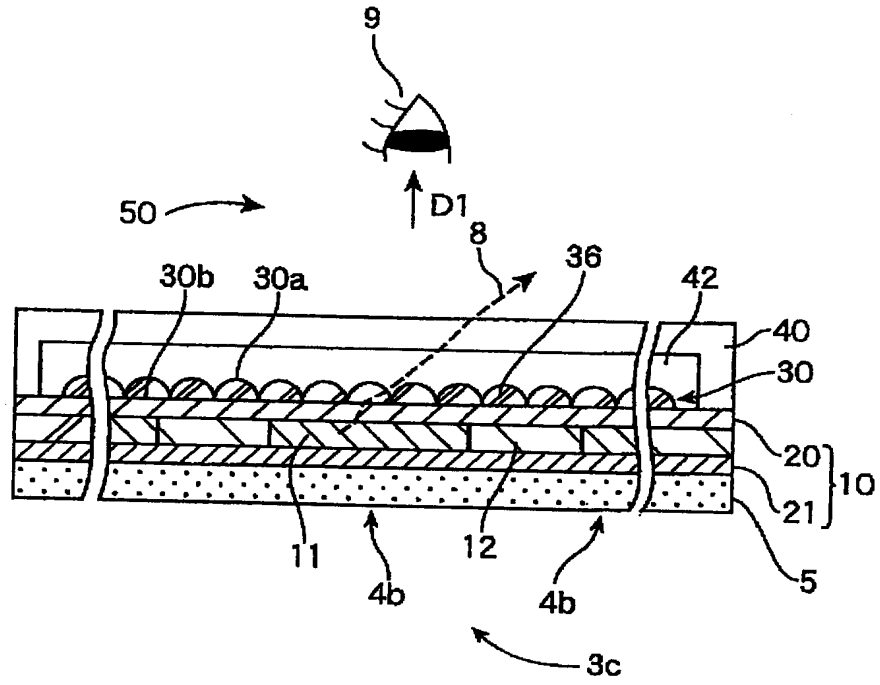
9
50
D1
8
36
30b
30a
42
40
30
20
21
10
11
12
4b
4b
5
3c

FIG. 10

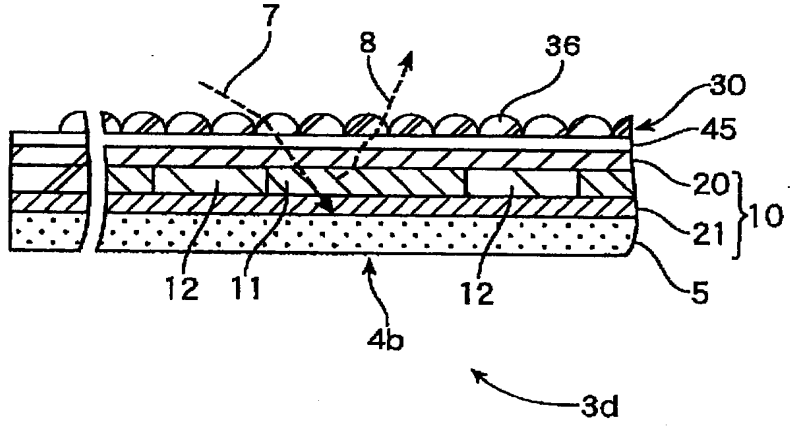
7
8
36
30
45
20
21
10
12
11
12
5
4b
3d

FIG. 11